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DEPARTMENT OF THE INTERIOR,

BUREAU OF EDUCATION,

WASHINGTON, D. C.

# SCIENCE TEACHING IN SECONDARY SCHOOLS IN THE WAR EMERGENCY.

## INTRODUCTORY.

The time has come for the Nation to make a more determined effort to secure for a larger proportion of our people a serviceable amount of technical and scientific training. Current developments are bringing to our people generally what has long been foreseen by a few leaders—some realization of the imperative need of a supply of engineers, scientists, and skilled mechanics beyond anything this country has known.

The appeals which have been made to our higher educational institutions are producing results, but in order that these may reach their highest efficiency we must in some way stimulate the schools of secondary and elementary grade.

Much can be accomplished in this direction if we can devise some means for exerting a great driving impulse behind the movement, already under way, to vitalize the instruction in science and the industrial arts in our public schools. We must thoroughly arouse communities that are now doing little or nothing in these fields to the gravity of the situation and to the point of energetic and purposeful action, and we must encourage all those communities which are already contributing something to do more and better than ever before.

Any program that will bring this about must be formulated with due consideration for all the factors involved and for the multitudinous difficulties with which it will be beset.

In April, 1918, the Bureau of Education issued a bulletin setting forth the views of certain Government departments at Washington with reference to the schools in war time. The demand for this bulletin and for further suggestions, together with important developments that have taken place during the past few months, indicate the need for a supplementary statement which shall define somewhat

more specifically ways and means by which the schools may contribute to the winning of the war and to the reconstruction which is to follow.

There has been an unprecedented demand in many departments of the Government service as well as in the essential war industries for workers of all ranks having some mechanical skill, or possessing technical and scientific knowledge, capable of being put to immediate practical use. The attempt to mobilize these workers has emphasized again the meagerness of the provision which has been made in this country for producing an adequate supply of scientists and technicians, and has revealed as never before the necessity for taking effective measures to meet the situation.

### CONFERENCE OF EDUCATORS.

To assist in formulating the essentials of a definite program, the Commissioner of Education summoned to Washington two groups of specialists to advise with him. A series of conferences during the week of May 20 resulted in the preparation of the following statement, including suggestions as to procedure in carrying out the recommendations. See also "Industrial arts in secondary schools in the war emergency," Secondary School Circular No. 4.

The membership of the conferences called by the Commissioner of Education included:

#### SCIENCE.

Clarence D. Kingsley, chairman, supervisor of high schools, State Board of Education, Boston, Mass.
Otis W. Caldwell, director, The Lincoln School of Teachers College, New York, N. Y.
James E. Peabody, head, department of biology, Morris High School, New York, N. Y.
George R. Twiss, high-school inspector, Ohio State University, Columbus, Ohio.
Calvin H. Andrews, principal, High School of Commerce, Worcester, Mass.
Thomas H. Briggs, professor of secondary education, Teachers College, New York, N. Y.
Earl R. Glenn, teacher of chemistry, Harrison Technical High School, Chicago, Ill.
W. H. Timbie, head, department of physics, Wentworth Institute, Boston, Mass.
J. W. Ritchey, head, department of physics, Hughes High School, Cincinnati, Ohio.
F. F. Bunker, Bureau of Education, Washington, D. C.

#### INDUSTRIAL ARTS.

William T. Bawden, chairman, Bureau of Education, Washington, D. C.
Alfred P. Fletcher, assistant superintendent of public schools, Rochester, N. Y.
William J. Bogan, principal, Lane Technical High School, Chicago, Ill.
Charles H. Lake, principal, East Technical High School, Cleveland, Ohio.
George F. Buxton, director, manual training department, Stout Institute, Menomonie, Wis.

Charles A. Bennett, professor of manual arts, Bradley Polytechnic Institute, Peoria, Ill.
Robert W. Selvidge, professor of industrial education, Peabody College for Teachers, Nashville, Tenn.
James A. Pratt, director of shops, Williamson Free School of Mechanical Trades, Williamson, Pa.
Arthur B. Mays, head, department of industrial education, Sam Houston Normal Institute, Huntsville, Tex.
William E. Roberts, supervisor of manual training, public school department, Cleveland, Ohio.

## THE NEED AND THE POINT OF VIEW.

The problem of producing competent scientific and technical workers in large numbers is immediate and urgent, and in the near future the need for such workers will be even greater than it is now. These workers include chemists, physicists, biologists, physicians, surgeons, experts in sanitation, engineering, agriculture, and others, in whose training science is an essential and highly important part.

The demand for scientific workers can be supplied only through appropriate science instruction given to larger numbers of students, and with a clearer and more constant recognition of the specific applications to the desired immediate military, industrial, social, community, and personal services to be given. So great is the demand likely to be that even the secondary schools must adjust their courses and programs so as to augment national resources. Fortunately this can be done by adopting generally the programs already in use by some of the most progressive schools. The war emergency has served to give clarity and emphasis to the movement already under way to make secondary courses in science contribute more constantly and effectively to practical needs. This practice should prevail, in order that a large number of future citizens may be interested in science, attracted to continued study, given appreciation of and respect for scientific processes, trained in the most useful phases of science, and thus enabled to become better citizens.

## GENERAL RECOMMENDATIONS.

1. Work in science, as in other subjects, at all times and especially in war time, should be made to contribute definitely to one or more of the following objectives: (1) Health of the individual and of the community; (2) command of fundamental processes; (3) worthy home membership; (4) vocational guidance and preparation; (5) citizenship in a democracy; (6) worthy use of leisure; (7) ethical character. In the present emergency items (1) and (4) should be particularly stressed.

2. To encourage high-school students to elect more work in science, and at the same time to lay a foundation for a general appeal to

science and its methods, every effort should be made to arouse a lively interest in science, particularly in grades 7 to 9.

3. In the present crisis training must be given for specific tasks, need for which has been created or made more emphatic by war conditions. Hence great and increasing emphasis must be laid on the applications of science to those processes most necessary in winning the war. Indeed, such immediate and purposeful real problems constitute the best basis for education in science whether in war time or not.

4. High schools are urged to provide science instruction adequate in kind and amount to make pupils competent in fields of science and industry in which they are needed for national service.

5. The schools should also undertake as a part of their duty the training of adults through night schools for tasks to which they are called by the national emergency. Wherever practicable, certainly in grades 7 to 9, in junior high schools, and the first year of four-year high schools, the artificial separation of the sciences so that they are treated as separate subjects should be ignored for the greater end of interpreting the problems of daily life. In solving a problem appeal should be made to any science that will contribute to the problem in hand.

## RECOMMENDATIONS CONCERNING THE SUPPLY OF SCIENCE TEACHERS.

1. The program for producing a larger number of scientific workers is conditioned on the supply of men and women who as science teachers do the work of giving such instruction.

2. The drafts made on the young men by the Army and the industries have caused a shortage in the supply of men teachers, while the drafts on the young women for war work and the highly paid industries tributary to the country's war needs are making scarcely less alarming inroads on the supply of available women.

### IMMEDIATE OR EMERGENCY SUPPLY.

3. Urge boards of education to repeal the rule, or disregard the precedent, against the employment of married women.

4. Issue a call through State departments, universities, National and State teachers' associations, to former teachers, especially married women and men not subject to draft, to resume work in the schools.

5. Provide means through which soldiers who are disabled, but competent for teaching, may be interested and brought into the schools.

6. Provide means to get farmers and industrial workers, who have been trained in agricultural and industrial courses, to teach agriculture or industries for part time in rural schools.

7. Organize agencies for summer training courses for emergency teachers and add for their further training (*a*) extension courses and (*b*) correspondence courses. Normal schools and colleges should be awakened to this great and immediate need.

8. Emphasize patriotic service in responding to emergency calls for teachers.

9. Specially needed teachers subject to draft should be enlisted and detailed to their schools for teaching service.

### SUPPLY OF SCIENCE TEACHERS FOR THE FUTURE DEMAND.

10. The profession of teaching must be made more attractive to persons of scientific capacities and training by—

(*a*) Higher salaries in order to compete with the industries; higher standards of preparation and fitness for work should accompany the higher salaries.

(*b*) Salary scales with increase based on teaching success, professional growth, and importance of educational influence.

(*c*) More recognition in the form of promotions to higher work:

(1) Extra salary grade for teachers of higher ability.

(2) To supervisorships of science teaching.

(3) To teaching or supervisory positions in normal schools.

(4) To professorships in colleges.

11. Teachers of physical science should be encouraged to find employment in shops, on engineering projects, and in scientific laboratories during at least a part of their summer vacations in order that they may be better able to maintain a closer relation between their instruction and the uses to which the instruction is applied; and teachers of biological sciences encouraged to engage in agriculture, orcharding, gardening, etc., for the same purpose. Teachers of earth sciences should be encouraged to engage in geological and topographical work, meteorology, etc., for the same purpose.

12. Colleges and normal schools must apply themselves seriously to the problem of attracting men and women toward science teaching and of selecting and properly training them for their work. Among the things that should be done are:

(*a*) Giving all science courses a distinctly experimental attitude and approach.

(*b*) Making the first courses in science humanistic and interpretive, in order that more students may be attracted into the higher and more intensive courses.

(*c*) Providing in each science department a teacher whose chief interest shall be the training of high school and college teachers and who shall give courses in his subject with that end in view. He should be not only a master of subject matter but also a successful

teacher. He should have had experience as a teacher in secondary schools.

13. Provide extension and correspondence courses for teachers in service. Make these worthy of full college credit. Such courses should cover:

(*a*) The subject matter of the science.

(*b*) Applications of the scientific method to problem solving in the science constituting the course.

(*c*) Methods of teaching the subject.

(*d*) Practical applications of the subject, especially to local industries and local social needs.

In some cases the deficiencies of inadequately prepared teachers may be made up in part by skillful and efficient supervision combined with training in service.

14. The agents of the State departments of public instruction and school inspectors should assist in the selection of high-school pupils showing promise of ability as teachers of science and in influencing them to enter on training for the profession.

## SUGGESTED OUTLINES OF COURSES.

### COURSES IN GENERAL SCIENCE.

#### 1. SELECTION OF MATERIAL AND ORGANIZATION.

The subject matter of general science should be derived from the environment of the pupils, and the course must necessarily vary in different localities. The particular unit most valuable is the one that truly interests the pupils, develops their best efforts, and prepares them for better service and better living. The courses must be flexible. It is quite possible, and consistent with the above purposes, to select units or topics which are of interest and value to an entire class and which provide coherence and give the best scientific training. The science of common use and the science of the school should be identical. No topic should be selected which is meager in content or in significant problems. The range of material used is in reality limited only by the capacity, experience, and needs of the pupils. While these materials should have practical values to the individual and the community, they should be concrete and lead to many avenues of new and untried experiences. In this very possibility of adjustment lies one of the strongest arguments for general science.

The topic-project-problem plan of organization is recommended. The topic represents the general unit to which several projects belong, the project representing some phase of this unit which presents itself for solution. In carrying out any project, many specific problems arise to be solved.

### 2. METHODS OF PRESENTATION.

In beginning any topic it should be viewed in perspective, so that the pupil's general relation to the topic is appreciated. This general view, if well selected, gives something known, very concrete, and significant, to which there is constant return and to which more detailed and more exact studies are constantly related. A combination of class representation of out-of-school experiences, of individual laboratory work, and of teacher and pupil demonstrations is desirable.

Simple materials should constitute most of the laboratory apparatus, since in comparison with the usual laboratory equipment they are more educative and less expensive. The desk demonstration by teacher or pupils is excellent as a means of presenting an experiment for observation and discussion, so that the attention of all may be definitely directed to the questions and observations. The demonstration should not always be made by the teacher, since pupil demonstrations have high value. Especially are they an incentive for the students to work out new problems of individual interest.

The individual laboratory method should also be used, since it gives individual opportunity to handle apparatus and individual chance for active participation. There is no objection to the same problem being solved by the whole class as individuals or groups, provided the class as a whole has been made to feel the importance of the work; but care must be taken when assigning all to the same task to see that the work does not become dead for part of the pupils.

Textbook discussion of subjects studied is important, but no text in general science can or should supply answers to all inquiries. The text should be used as a reading and reference book. Other available sources of reading material should be extensively used, such as magazine articles which discuss current use of science. Specific references should be made for children of the age of general science pupils, since they will read widely if they know just what to read. Excursions, well directed, with a purposeful aim, are of great value. But to be effective, excursions must be well planned and the experiences and observations of excursions must be utilized in later class work.

### 3. SAMPLES OF TOPICS FOR GENERAL SCIENCE COURSE.

It is not desirable that there be a syllabus of a course to which all teachers shall adhere, but rather that sufficient topics be presented to indicate clearly the kinds of materials recommended. To make these suggested topics of greatest value, enough topics are presented to compose a fairly full course for one year's work. The topics here presented were organized by the teacher of general science in a city of approximately 150,000 inhabitants. It is presented as an illus-

tration, not as a scheme to be followed closely. In other cities, for example, a small city in a strictly agricultural community or a large city in a commercial or manufacturing community, many other topics and problems should be substituted.

*Topic I. Combustion.*—Sources of heat; kinds of fuels; making a bonfire; list of questions about bonfires; why the fire burns; lesson on elementary chemistry; elements and compounds; what becomes of wood when burned; oxidation; heat produced by oxidation; making a thermometer; effects of heating; water heats slowly; thermostat; how heat travels; ways for heating a home; how the science room is heated; study of a chimney; what smoke is; how illuminating gas is made; how gas is made in this city; study of candle flame; of Bunsen burner; applications; carbon dioxide; application; carbon dioxide in relation to physiology; control of fires; losses from fires; how to prevent them; what is a fire insurance company; does the insurance rate in this city indicate that fires are more or less common than elsewhere?

*Topic II. Water.*—Changes from one form to another; relation of heat to these changes; changing water to steam; evaporation; ice machines; changing vapor to water; condensation; dew, rain, frost, snow; distillation and applications; transpiration; running water, where from, where going, rate of flow; erosion and its effects; erosion and forests; erosion and crops; erosion and farm values; influence of bodies of water on climate; fruit belt and large bodies of water; composition of water; water in relation to health problems; distribution of bacteria; typhoid as illustration; water supply and sewage disposal; source of water; impurities; water system; sewers; various methods for disposal; the one here used; industrial uses of water; water a solvent; relation to household use; relation to plant and animal life; uses in industries; relation to geography; mill ponds and dams; water pressure.

*Topic III. The air and the weather.*—Does air occupy space? Why can one kick a football farther when inflated than when empty? Does air have weight; determine weight of air in classroom; air pressure; common pump; meaning of pressure; barometer; biography of Galileo and Torricelli; story of making first barometer; distinction between weight and pressure; moisture in air; effect on weight of air; relation of temperature and atmosphere to moisture in air; relation to health; dew point; frost; rain, dew, air pressure, and winds; highs and lows; weather map; how forecasts are made; rainfall; map; importance of distribution of rainfall; composition of air; impurities; bacteria in air and water.

*Topic IV. Distribution of bacteria and other disease germs.*—Distribution of bacteria; bacteria upon carelessly handled bread; importance of pure milk and water; results of improved hygienic conditions; typhoid carried by flies; the life history of house flies; how flies carry bacteria; disposal of house flies; cleanliness and disease; mosquitoes and malaria; malaria caused by an animal organism; the life history of the mosquito; how mosquitoes carry malaria; how to destroy mosquitoes; disease germs distributed by other insects.

*Topic V. Light and its benefits.*—How things are visible; intensity of illumination; measuring the light; reflection; refraction; color; photography; artificial lighting; benefits of light; sunlight and health.

*Topic VI. Work and energy.*—Work by running water; machines; mills run by water power; pumps; elevators; gasoline engine; steam engine; biography of James Watt; mechanical energy and heat.

*Topic VII. Magnetism and electricity.*—Wire electric bell to battery; connect automobile lights in series and parallel with battery or storage cell; study

electric toaster, coffee percolator, laundry iron, and other heating appliances; use of fuses; motor attachments for sewing machine, suction cleaner, etc.; study of simple generator, such as the Ford engine; possibly, the individual light and power unit for the farm or home.

*Topic VIII. Nature's balance of life.*—Clover, rabbit, fox, wolf, men—an illustration; overproduction; potatoes; limiting conditions; why some forms stay; others do not; biography of Charles Darwin; artificial selection; good seed; germination; soil as source of plant-life food; removal and replenishment of soil elements; why a plant needs water; how water rises through the soil; how liquid goes from cell to cell; food factories for all living things; leaf structure; light and chlorophyll; products and by-products; which plants and animals are to live; the nature of variation; hybrids; natural and artificial selection; changes in environment; results of natural selection; artificial selection; progressive results of artificial selection; heredity and the future of the race.

## COURSES IN BIOLOGY.

In most cases courses in biology will have been preceded by work in general science. In some schools biological work is most profitably done as general biology and in some schools as separate courses in botany and zoology. The following suggested outline by adjustment may be made of use in either type of biological course. It is not necessary to outline these courses as fully as was done in general science, since there is a more general understanding of the desired content of these courses. The general suggestions herein should receive definite and effective recognition in biological instruction.

In war time preeminently, and also in times of peace, instruction in biology should include (1) food production and preservation, (2) production and use of the biological materials of industry and commerce, (3) conservation of other natural resources, (4) personal hygiene, (5) home and community hygiene, (6) conservation of human inheritance. The effective study of these topics should be required of all high-school pupils, with such adjustments in the particular subjects—biology, botany, zoology—as are necessary to fit different school curricula. In the present emergency suitably equipped schools should give special training to boys and girls adapted thereto which would equip them to serve as assistants in agricultural, sanitary, and bacteriological work and food laboratories and as assistants to doctors and nurses.

1. *Food production and preservation.*—The United States Government and the Governments of other countries are constantly emphasizing the great problem of food supply. Plants which produce our cereals, our sugar, our vegetables, and other foods are of supreme importance, and never before were we so urgently in need of knowledge of the best processes for production of foods and of preventing food destruction by insects, bacteria, and molds. Information from the local and State food authorities should be used in classes so that pupils may know the needs of the country.

Careful surveys of the local environment should be made to discover especially effective methods of food production and especially destructive agencies,

and there should be developed a scientific understanding of these situations so that further improvement in practice may result.

2. *Production and use of biological materials of industry and commerce.*—The fiber industries may be used as illustration. Cotton is the determining factor in times of war and peace. Fibers for cordage are of great importance. Pulp for paper making is similarly important. Biology should develop an understanding of the nature and significance of these things, and a sense of obligation in conserving these and other products.

3. *Conservation of natural resources.*—The entire question of conservation of natural resources should receive constant attention. In the study of nutritive and reproductive processes in plants, structure should be taught only so far as is necessary for the understanding of function and of relations to human welfare; uses of plants (especially forest, orchard, agricultural, garden, and house plants); useful animals (especially fish, birds, and mammals of economic importance); extermination of weeds, harmful insects, and rodents; waste of soil or soil-making materials. The attitude of careful use and elimination of waste should be thoroughly instilled.

4. *Personal hygiene.*—Personal hygiene should be taught in such a way that the pupil will be led to apply the lessons in every day living. Essential topics: Structure and hygiene of the skin; bathing; clothing; structure and care of the teeth; choice of food and drink; hygienic habits of eating; care of digestive system; structure of the nose and throat; adenoids and tonsils; brief consideration of structure and adaptation of skeleton and muscles; posture; hygiene of muscles; importance of work; sleep and play; daily health routine; dangers of stimulants and narcotics, natural defences against disease; first aid to the sick and injured.

5. *Home and community hygiene.*—Essential topics: Water; food supply; drainage; ventilation; methods of sweeping and dusting; extermination of flies; mosquitoes and other household pests; beneficial and injurious bacteria; food preservation and preparation; antiseptics and disinfectants; recognition of ordinary symptoms of common diseases; work of board of health.

6. *Conservation of human inheritance.*—The positive biological, social, and ethical aspects of this topic should be emphasized and the pathological viewpoint should seldom be mentioned in dealing with boys and girls. So-called sex education should be given only by those teachers who are specially trained for such instruction. Courses dealing with the following topics should be given to parents and social workers and in normal and university training courses:

Essential topics: The gradual development of the process of reproduction in lower plants and animals and in the higher plants and animals; the normal aspects of the functions of reproduction; dangers in bad habits; infections which influence human inheritance, and ways in which they are transmitted; relative influence of heredity, environment, and training; physical, intellectual, social, and ethical helps to clean and effective living.

### COURSES IN PHYSICS.

1. *Simple phenomena.*—Lessons on simple phenomena, process and appliances in the domain of physical science, i. e., elementary physics, chemistry, and astronomy, should be given as a part of the science course throughout the elementary grades, especially grades 7 and 8. These lessons should be simple, interesting, and largely informational in character, and should be given in harmony with the

general statement outlined above, on pages 6 and 7. In order to make such lessons effective, competent supervision should be provided for the science instruction in these grades.

2. *Common appliances.*—The introductory course in physics should cover the most important appliances (1) of the home and school; (2) of public utilities; (3) of the industries and agriculture, particularly those closely related to the immediate environment; and (4) especially in view of the present conflict, some of the numerous and interesting appliances and physical principles essential to the prosecution of the war. The course should be given in either the third or fourth year of the high school.

3. *Electives.*—In schools where it is feasible, one or more special courses should be offered as electives. The aim of such electives should be to extend the knowledge gained in the first course, so that a group or groups of pupils may become competent to apply it in some vocation or war service. Household heating, cooking, ventilating, lighting, and electrical appliances or optical instruments, color phenomena, and photography; or telegraphy, telephone, and signaling; or projectiles, airplanes, balloons, and dirigibles; or gas engines and automobile work; or magnetos, motors, dynamos, transformers, storage batteries, wiring, and lighting would be suitable subjects for such advanced electives in applied physics.

4. *The problem method.*—The approach to every principle that is taught should be through the study of some fairly simple appliance in whose design or use the principle is involved. This is the "problem or project" method, or inductive approach, which exemplifies the method of science in solving problems. For the pupil it is the only sure way of getting command of a principle so that he can apply it to new cases. Furthermore, conditions demand that the boys and girls shall have direct and positive information which can be put to immediate use.

5. *Organization.*—The brief outline which follows is suggestive of the groups and types of devices that should serve as centers of organization in the first course. It is not intended as a prescription of subject matter either as to content or order. It is expected that the teacher will organize the lessons so as to use the devices and the questions suggested by them as starting points and basis for problems and projects out of which the apprehension of general principles and laws will naturally grow. The final organization of subject matter according to the leading principles of the science should be carried out by the class under the guidance of the teacher in connection with reviews.

*Suggested topics bearing on military activities.*—Simple bridge structure, derricks, moving and hoisting tackle, present numerous appliances through

which we may teach the principles underlying the composition and resolution of forces, moments, and the strength and proper distribution of materials.

Trench pumps, ships, submarines, balloons, serve the same purpose for fluids.

Automobiles, steam engines, and water motors should be used as the starting points in teaching of work, energy, and power relations.

The construction and action of guns and projectiles are points of contact for introducing ideas of force, mass, and acceleration.

The generation, distribution, and use of electricity for charging defense wire, lighting quarters, and communicating by telephone and telegraph offer an abundance of materials for approaching the laws of electricity.

Range finders, photographic apparatus, periscopes, heliographs, telescopes, and camouflage devices supply centers of interest for the practical study of optics and color phenomena.

Apparatus for detecting submerged submarines, the detector of concealed guns, and the devices for underwater signaling may be used as a basis for instruction in the principles of sound.

Topics drawn from home and school, from public utilities, from local industries, and agricultural activities readily lend themselves to similar treatment.

## COURSES IN CHEMISTRY.

On account of the fact that technical war needs seem to relate even more to chemistry than to some other sciences, a somewhat fuller outline is given of developments and needs in this science.

### RELATION OF CHEMISTRY TO THE HIGH-SCHOOL SCIENCE ORGANIZATION.

Chemistry should be a part of a progressive science sequence in the four-year and the six-year high-school programs. In most cases it should be given in one of the last two years of the high-school course. It should be preceded by at least one year of general science, one year of biological science, and in most cases by one year of physics. One year should be devoted to a first course in chemistry, in which the general principles and essential information of the subjects are developed by experimental methods. In some high schools, as those with environments which have special industrial or technical needs, it is advisable to have special courses in chemistry of a vocational nature. These should be determined by the local needs through conferences with local authorities.

### CONTRIBUTIONS CHEMISTRY MAY MAKE IN SPECIFIC WAR WORK.

*The special need.*—The industrial center presents specific and difficult problems for the high school. The teachers of chemistry should study the local situation to determine what war activities, if any, can be aided by the courses in chemistry, and then military men, employers, industrial foremen, etc., should be consulted, and, as a result of these conferences, a plan of procedure should be evolved by which the courses in chemistry can be put into operation. It will aid

materially if the teachers emphasize the occupational aspects of chemistry and skilled technical work. This can be done by visits to industrial plants, by assigned readings from up-to-date books on vocational and technical subjects, and by asking local military and industrial men to lecture on various aspects of these subjects. Through these activities students will learn to appreciate the importance of chemistry in the present situation.

*Content of the courses.*—When the needs are known the chemistry course should be determined by the funds available, by the school organization and equipment, by the teachers available, and by the possibility of obtaining information from men in the locality who are familiar with the industrial demands.

*Chemists' apprentices.*—Some provision should be made in our educational system for the training of boys during the high-school period in such technical subjects as will fit them for positions as chemists' apprentices. Chemists' apprentices should have had the equivalent of a high-school course which includes:

> Arithmetic through elementary algebra; general science and biology; elementary physics; elementary chemistry; elementary mechanics; elements of mechanical drawing; considerable manual training, especially woodworking and machine tool work of the simpler sort.

A chemical works manager says:

> We like to provide most of our chemists with one or more of such apprentices. By so doing we enormously increase the output of the trained chemist and at the same time we train up a valuable corps of assistants who, for some purposes, are more satisfactory than the college graduate. We fully appreciate that the educational problem involved is purely a local problem for, according to this plan, each community must shape its technical high schools or trade schools according to the needs of the industries of that particular section.[1]

### GENERAL CONTRIBUTION TO WAR WORK.

Communities which are not required to make direct contributions to war industries find themselves in need of reorganizing the courses in chemistry in order that they may serve community needs better than is true now. The agricultural, civic, household, and industrial needs, as related to high-school chemistry, require that chemistry shall incorporate more of the features which touch agriculture, civic life, the home, and the industries.

It is therefore urged that effort be made to provide and equip laboratories so that more of the knowledge of chemistry suggested above may be disseminated. These needs require that teachers of chemistry know the uses of chemistry, and communities should try to secure teachers who have had first-hand contact with at least some of the situations in which chemistry is applied.

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[1] Jour. Ind. and Eng. Chem., August, 1917, p. 799.

While there are over 100,000,000 people in the United States, there are only about 15,000 chemists. It is not the purpose of the high school to make chemists of the very great number of students enrolled in high-school chemistry. However, some of the students may become assistants in laboratories, some may go to college to become chemists, but these suggestions refer primarily to the needs of the great majority. In addition to giving instruction for any specific war work which can profitably be done, it is important that we try to give pupils an idea of what chemistry is about, what it has done and is now doing in America and in the world at large, and, if possible, teach the subject so that pupils may know when to seek the services of a responsible chemist in the solution of problems of importance to manufacturers, business men, doctors, farmers, etc.

### METHODS OF TEACHING.

1. Chemistry should be taught by use of a large amount of individual experimental work on the part of teacher and pupil. The information thus gained should be supplemented by readings from up-to-date texts, reference books, and technical magazines.

2. As an illustrtion of what is now expected of an advanced course in chemistry for special students in the subject, the following is quoted:

> There is a great gulf fixed in the minds of most students between the application of science in the laboratory where the environment is such as to make calculation easy and the factory where conditions are such as to make necessary at best a scientific guess. The student of applied chemistry is now asked:
>
> 1. To study the chemical control of industrial processes through the laboratory and to acquire ability in the interpretation of laboratory data in terms of factory practice.
> 2. To acquire a first-hand knowledge of the processes of the plant and the machines with which it is equipped.
> 3. To obtain the wider viewpoint which comes from contact with those who are employed to superintend or to carry on the factory operations, and to acquire the degree of confidence in handling large-sized apparatus which comes from actual participation in the active work of the plant.
> 4. To acquire that inspiration for further work in science and research which intimate contact with large progressive industries inevitably affords.[1]

### TOPICS EMPHASIZED BY THE WAR SITUATION.

The following topics should be used in appropriate places in the chemistry course:

### CHEMISTRY IN WAR SERVICE.

1. *Methods of gas warfare.*—There are three things that really matter in gas warfare. They are (1) increased concentration; (2) surprise in tactics; (3) use of unexpected new materials.

[1] Jour. Ind. and Eng. Chem., December, 1917, p. 1087.

Among others, the following compounds have been used by the Germans in gas clouds or in shells: Benzyl bromide, bromo-acetone, allyl mustard oil, bromo-ketone, bromine, chloro-acetone, chlorine, mustard gas, dimethyl sulphate, phosgene, and sulphur trioxide.[1]

2. *The potash situation.*—The need of potash in manufacture of fertilizers is very great. We need not only understand the uses and sources of potash, but the following quotation shows the importance in the war of the potash deposits in one part of the war zone:

> If Germany should lose Alsace, the potash supply for many years would be assured to the rest of the world for a period long enough either to reestablish friendly relations or, if that may not be, to bridge over the space of time which must elapse before the known non-German deposits can be made available or new deposits found by careful and systematic search.[2]

The potash deposits of Alsace consist of two beds of chloride of potassium which lie in an intercalated rock salt deposit nearly 800 feet thick. The total quantity of pure potash is estimated at 300,000,000 tons.

3. *Chemicals of special importance in war work.*—The following chemicals are extensively used in war industries and when studied should be related to these uses: Sulphuric, nitric, and acetic acids, ammonia, manganese, steel, mercury, magnesium, abrasives, chlorates, phosphorus, graphite, chlorine, and toluol. In 1915 there were approximately 44,000 ounces of platinum in contact acid plants; in 1917, about 60,000 ounces; and it is estimated that the supply must be further expanded during 1918 by at least 50 per cent to supply the sulphuric acid to make the munitions necessary to carry on the war. We should, therefore, teach students that the legitimate place for platinum is in such uses as suggested by the War Department. Information regarding chemicals which may not be exported, and on the importance of various inorganic chemicals as related to war needs, may be obtained from the export lists published by the United States Government.

4. *Other substances of which we have no appreciable supply.*—Among others the instructor might call attention to iodine, antimony, manganese, platinum, nickel, potassium salts, tin, and nitrate deposits.

APPRECIATION OF THE IMPORTANCE OF CHEMISTRY IN NATIONAL LIFE.

1. *Chemical service section of the National Army.*—The high-school teacher should acquaint students with the general organization and work, so far as it is reported, of the chemical service section of the National Army. It is not only in war work but in many other lines that the chemist can show how to save waste, reduce cost, and make life more comfortable and effective.

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[1] Jour. Ind. and Eng. Chem., April, 1918, p. 297.
[2] Ibid., May, 1918, p. 407.

2. *Fields in which American chemists are now at work:*

(*a*) Service at home—

(1) As teachers.

(2) Control and direction of industrial operations; manufacture of munitions, poison gas, gas masks, smoke bombs, signaling devices, motor fuels, drugs, dyestuffs, rubber, metal goods, etc.

(3) Inspection, testing, analysis of manufactured products; detection of new poison gases, detection of poison in streams and wells.

(4) Development of new plants and processes; nitrates, toluene, glycerol, sulphuric acid, caustic soda, etc.

(5) Small scale manufacturing operations.

(6) Advisors to the Government.

(7) In Government chemical laboratories; to fill places made vacant by the draft.

(*b*) Service abroad—

(1) With our forces in France: Sanitary Corps, Poison-Gas Service, Ordnance Department, Engineer Corps, Quartermaster Corps.

(2) In the laboratory and chemical industries of our allies, where competent chemists are sorely needed to fill the ranks thinned by the war.

3. *Chemists classified by chief industrial groups.*—Secure a copy of Technical Paper 179, published by the Bureau of Mines, and encourage the students to become familiar with the general work of the 15,000 chemists as classified in this bulletin under 45 groups.[1]

4. *Normal growth of American chemical industries.*—It is well to emphasize the importance of the growth of American chemical industries. The high school is an important factor in giving the general public some reliable information on the function of chemistry in a democratic nation. The growth of chemical industries in normal times has been large, as may be shown by inspecting any comprehensive census report.

5. *Development in chemical industries as the result of war conditions.*—Students should learn in a general way the methods used in solving some of the immediate and difficult problems in the following fields:

*a*. The fuel problem.

*b*. Coke and by-product chemicals, such as gas, ammonia for fertilizers and munitions, benzol for colors, toluol for explosives, carbolic acids for antiseptics, explosives, creosote, oils for wood preservation.

*c*. Dyestuff industry.

[1] Jour. Ind. and Eng. Chem., April, 1918, p. 322.

*d*. Munitions: The substances from which the three main types of explosives are made are glycerine, phenol, and toluol.

*e*. Benzol, in its various uses.

*f*. The world situation with reference to gasoline.

*g*. Potash supply for the United States.

*h*. Optical glass.

*i*. The production of nitrates.

*j*. The production of sulphuric acid and the manufacture of new apparatus for the acid industries.

6. *War contributions of electrochemistry.*—Hundreds of machine shops are dependent on the electrochemical abrasives, carborundum, and alundum; thousands of rifles and guns are turned out every month with the aid of high-speed steel made from electric ferro-alloys; millions of pounds of electrolytic copper are essential for our electrical apparatus. There is the aeroplane whose light, strong stays are made from the electrochemical metals, aluminum and magnesium; there is liquid chlorine, a product of the electrolytic cell, and the basis of the Carrel-Dakin method of treating the wounds of our heroes; there is electrolytic hydrogen used in all of our scout and observation balloons, and there are the numberless electric alloys entering into the composition of nearly every item of the Government's vast military equipment.

7. *Ability and productivity of American chemists.*—Discourage the idea that all of the world's capable chemists are now in Germany. The ability of a chemist depends upon the man and his education, not upon his nationality. A recent article in reference to this subject says:

> The United States and Germany have exchanged places, Germany having been first by a big lead in 1913, and United States second, and vice versa in 1917; it is to be noted that the lead of the United States in 1917 is greater than the lead of Germany in 1913.
>
> Great Britain has maintained her relative position with almost no variation. The number of papers published in the neutral European countries has fallen off considerably.[1]

## COOPERATION FOR SECURING INCREASED SUCCESS THROUGH SCIENCE TEACHING.

It is of the greatest importance that close cooperation in purpose and administration be secured between all studies which contribute to the emergency needs, for it is recognized that many secondary school subjects besides the sciences can make specific contributions needed in this emergency.

In every school increasing attention should be given to opportunities in vocations requiring scientific knowledge and skill.

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[1] Jour. Ind. and Eng. Chem., March, 1918, p. 237.

To aid in this work universities and other educational agencies should issue bulletins briefly setting forth the opportunities and character of work in each vocation in which science training is an important factor.

The principal and teacher should study the local situation to determine what war activities can be aided by the sciences and other subjects tanght in the high school. Possible contributions should be listed and discussed until a definite plan of work is arranged.

## REPORT OF THE SCIENCE COMMITTEES OF THE COMMISSION ON REORGANIZATION OF SECONDARY EDUCATION.

The science committees of the Commission on the Reorganization of Secondary Education, appointed by the National Education Association, have for some years been preparing a comprehensive report on science teaching. This is soon to be issued by the United States Bureau of Education. The foregoing recommendations are consistent with this more extended report. Following is a brief summary of the contents of this more extended report:

Introductory. Why courses in science in secondary schools need reorganization with special recognition of war emergency needs.

I. General aims and purposes.
   - A. Contributions of science toward general educational objectives.
     1. Health.
     2. Home membership.
     3. Vocational preparation and participation.
     4. Citizenship in a democracy.
     5. Use of leisure time.
   - B. Special values of science study to the individual.
     1. Actual contact with real materials.
     2. Development of specific interests, habits, and abilities.
     3. Stimulation to discovery of individual aptitudes.
     4. Informational values.

II. General principles and methods controlling science instruction in secondary schools.
   - A. Point of view in organizing work.
     1. The units of study.
     2. The natural way of study.
     3. Disadvantages to be avoided.
     4. Considerations determining choice of projects and topics.
     5. The advanced courses in science.
   - B. Laboratory procedure.
   - C. Classroom procedure.
   - D. Cooperation between pupil and teacher.
   - E. Cooperation between school, home, and community.

III. Science curricula.
   - A. The large composite four-year high school, 500 pupils or over.
   - B. The medium four-year high school, 200 to 500 pupils.
   - C. The small high school, 200 or fewer pupils.
   - D. The junior-senior high-school combination.
   - E. Technical, manual training, and commercial high schools.

IV. General science.
- A. Why reorganization of general-science courses is necessary.
- B. Selection of materials and organization.
- C. Methods or presentation.
- D. Suggested samples of topics for content of course.

V. Biology.
- A. Why reorganization of courses in biology is necessary.
- B. Specific applications of general aims to biology.
- C. Possible ways of organizing courses to follow logical principles of sequence and development.
- D. Methods of presentation.
- E. Content of the courses in biology.

VI. Physics.
- A. Why reorganization in physics is necessary.
- B. Application of general aims to physics.
- C. Selection and organization of materials.
- D. Methods in teaching physics.
- E. Content of courses in physics.

VII. Chemistry.
- A. Why reorganization of chemistry is necessary.
- B. Specific aims and purposes in chemistry.
- C. Selection of materials and methods of representation.
- D. General divisions of the course.
- E. Suggested topics more fully outlined.
- F. Modified chemistry courses for different types of high schools.

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